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Fixation of Displaced Intra Articular Calcaneal Fracture Through Sinus Tarsi Approach

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Abstract

In the past, the surgical management of displaced intraarticular calcaneal fractures has been a contentious issue. Soft tissue problems and concurrent disease must be taken into account in individuals with this syndrome. Stability, anatomic reduction of the fracture, and preservation of soft tissue may all be achieved with the minimally invasive sinus tarsi technique. The purpose of this thesis was to evaluate the result of fixation of displaced intra-articular calcaneus fractures using sinus tarsi approach. Methods: This prospective clinical study included twenty adult patients suffering from recent displaced intra-articular calcaneal fractures from September 2020 and august 2021 that were treated by open reduction and internal fixation through minimal invasive sinus tarsai approach in Orthopedic department of Benha faculty of medicine and Meniet-Elnasr general hospital. After 6 months follow up, mean of AOFAS score was 90.25 ranged from 74 to 99. Mean of Bohler angle was 27.25° and mean of Gissane angle was 122.65°. Regarding patient's outcome according to AOFAS scale, 14 (70%) of patients showed excellent results while 4 (20%) of patients showed good results and 2 patients (10%) showed fair results. There was a statistically significant correlation between AOFAS score and (postoperative Bohler angle) while no significant correlation was founded between AOFAS score and (Age, Sex, preoperative and postoperative Gissane angle). There was a statistically significant correlation between Sanders type and (Age, preoperative Bohler angle) while no significant correlation was founded between Sanders type and (Sex, preoperative and postoperative Gissane angle). Conclusion: Sinus tarsi approach is a less invasive method for treatment of calcaneal fractures. It permits good visualization of the fracture, and allows anatomic reduction of articular surfaces with a decrease of wound complications and shorter waiting time before surgery. It is a valid option of treatment for displaced intra-articular calcaneal fractures with more advantage to Sanders type II.

Key words: displaced intra articular calcaneal fracture - Fixation - sinus tarsi approach.

1. Introduction:

Calcaneal fractures include more than 60% of tarsal bone fractures; this pathology affects adult males more frequently and has a high socioeconomic cost [1].

The fracture mechanism is typically high energy axial load on calcaneus bone caused by a fall from a height or a road traffic accident [2].

Regarding the involvement of the articular surface, calcaneal fractures are descriptively categorized into extraarticular and intra-articular types. The compression of the talus against the calcaneus is responsible for the intra-articular type, while extra-articular fractures are avulsion injuries arising from twisting or shearing forces. The outcome of extra-articular fractures is, on average, better than intraarticular types. The classification system was defined by Sanders, based on computed tomography scan findings, Intra-articular calcaneal fracture is one of the most challenging fractures for the orthopedic surgeons all over the world to treat properly, Open reduction and internal fixation (ORIF) via an extensile L-shaped approach is one the most popular approach. This popularity is due to osteosynthesis through restoring anatomical calcaneal alignment and congruity of the posterior facet of subtalar joint. In this technique, neither joint trans fixation nor long-term immobilization is not necessary [3].

Treatment of displaced intra-articular calcaneus fractures remains a challenge and the optimal treatment is still controversial [4].

When calcaneus fractures are treated surgically, reduction and fixation is often challenging and is associated with relatively high complication rates, although traditional extended L-shaped lateral approaches for open reduction and internal fixation (ORIF) offer good fracture visualization and direct reduction of the posterior facet fragment and lateral wall, they also have high rates of wound complications and infection of up to 37% and 20%, respectively [5,6,7].

The vascular supply of the lateral hindfoot is dependent on the lateral calcaneal branch of the peroneal artery and is particularly vulnerable to disruption after extended L-shaped lateral approaches [8,9].

Recent, less invasive surgical techniques for treating displaced calcaneus fractures have been undertaken in an attempt to help reduce complications and improve recovery when surgery is indicated, These early investigations reported lower complication rates and promising clinical and radiographic outcomes in certain fracture patterns and patient populations, Innovative techniques include limited-incision sinus tarsi ORIF, percutaneous stabilization with pins and/or screws, and arthroscopic assisted fracture reduction[10].

A thorough understanding of the clinical and radiographic anatomy of the calcaneus and its articulations is crucial when attempting less invasive procedures for intra-articular calcaneus fractures. These emerging techniques may be beneficial in patients with soft-tissue compromise, multiple comorbidities, and displaced intraarticular fractures with minimal comminution. However, further research is needed to determine the ideal candidates for these procedures, as well as long-term outcomes [11].

Literature suggests an advantage of operative treatment over non-operative management, with the greatest benefit in patients with displaced intra-articular fractures, patients with reduced Böhler's angle, and

young, active, light to moderate working and compliant, non-smoking patients [12].

The purpose of this study was to evaluate the result of fixation of 20 cases of displaced intra-articular calcaneal fractures through sinus tarsi approach.

2. Patients and methods

This prospective clinical study included twenty adult patients suffering from recent displaced intra-articular calcaneal fractures from September 2020 and august 2021 that were treated by open reduction and internal fixation through minimal invasive sinus tarsai approach in Orthopedic department of Benha faculty of medicine and Meniet-Elnasr general hospital.

Inclusion criteria:

All patients with recent displaced intra-articular calcaneus fractures ≤ 3weeks from time of trauma, closed fractures, Age from 18 to 50 years old and Sanders's type II.

Exclusion criteria:

Open fractures, Extra articular fractures, Associated neurovascular injuries, Medical co-morbidities, Pathological fractures and Sanders's type III and IV fractures.

Patient counseling:

This was a crucial part of the study. The management plan included the necessary investigations, operative details and time schedule after the surgery needed for rehabilitation was discussed in detail with every patient. This counseling was essential to make the patients more comfortable and cooperative, written informed consent was taken from every patient.

Clinical examination:

General examination:

This was done to assess every patient's general fitness for the surgery, Pre-assessment of the patient by anesthesiologist was done to identify prerequisites of surgery, Examination of the spine and any associated injuries especially in cases of fall from height.

Local examination:

Meticulous local examination of the affected Foot was done for each patient, Inspection usually revealed the deformity, localized swelling over the heel, ecchymosis, The heel might appear shortened relative to the other side and may be broad, A careful neurovascular examination was performed for assessment of the integrity of the neural and vascular structures related to the foot.

Radiological examination

Plain Radiography

Plain X ray Lateral view of the ipsilateral hindfoot were obtained preoperatively to determine Böhler's and Gissane angles, axial view to obtain varus-valgus deformity, Antero-posterior x-rays of the feet were obtained to exclude calcaneo-cuboid joint affection.

CT scan assessment of articular surface wase done

3. Technique

A 2 to 4 cm incision was made over the sinus tarsi following a line from the tip of the fibula to the base of the fourth metatarsal **(Fig. 1)**. Dissection is carefully carried down to the posterior facet as the extensor digitorum brevis is retracted proximally and the peroneals retracted posteriorly to avoid damage, there is often fibrous debris and fat within the sinus tarsi that needs to be removed with a small rongeur in order to properly visualize the articular cartilage, A C-arm is brought in from the ipsilateral side to facilitate acquisition of multiple lateral foot, and axial heel radiographs. The depressed posterior facet is directly visualized and a knife is used to sharply demarcate the exposed borders of the fracture fragment. A small periosteal elevator is then placed under the posterior facet fragment to elevate it up into an anatomic position, The Steinman pin maybe used as a joystick, the Steinman pin and the elevator are used to lever the posterior fragment into place **(Fig. 2)**. Once the posterior fragment is anatomically reduced, K-wire is inserted into the fragment and across the subtalar joint into the subchondral bone of the talus to hold the fragment in a reduced position. K-wires ranging in size from 1.5 to 2mm according to the size of the displaced fragment, After confirming calcaneal length, height, and Gissane and Bohler angles, one or two K-wires that allowed passage of canulated partial cancellous 4 mm were introduced from lateral calcaneus to the medial calcaneus through subchondral bone to support the posterior facet under the guidance of C-Arm fluoroscopy **(Fig. 3)**.

Fig. (1) Intra-operative photo skin incision: A3cm incision was made over the sinus tarsi.

Fig. (2) Intra-operative fluoroscopic image photo showing The Steinman pin and small periosteal elevator are used together to lever the posterior fragment into place**.**

Fig. (3) Intra-operative fluoroscopic image photo: permanent osteosynthesis with two 4 mm canulated partial cancellous screws.

If the fracture line extende posterior as in tongue type , we can take screw from supperior to inferior prependiculer to fracture line in ordere to close fracture. After the calcaneus was reduced satisfactorily under C-arm fluoroscopy, a permanent osteosynthesis was acquired with A small mini fragment buttress plate that may be placed from the articular rim of the posterior facet to the anterior process region to buttress the articular reduction and help to maintain the crucial angle of Gissane **(Fig. 4)**. If there is **varus malalignment** of the heel, a percutaneous Schanz pin was placed in the calcaneal tuberosity which was fixed by temporary K-wires. After verifying calcaneal length, height and width, a guide pin for a 6.5-mm partially threaded cannulated screw was inserted posteriorly lateral to bony prominence directed into the anterior aspect of the calcaneus The Steinman pin was then removed and Afterward, permanent osteosynthesis was acquired with 6.5-mm canulate partial cancellous screw, this screw help to maintain calcaneal varus-valgus alignment, height and support the posterior facet **(Fig. 5)**. Closure sub cutaneous layer and skin of the incisions. below knee backslap was done after closure **(Fig. 6)**.

Fig. (4) Intra-operative fluoroscopic image photo: assessment of plate and screws final position**.**

Fig. (5) Intra-operative fluoroscopic image photo: osteosynthesis with 6.5-mm partial cancellous canulated screws for varus alignment**.**

Fig. (6) Intra-operative photo: skin closure.

All cases were followed up clinically and radiologically for 6-12 months, mean 7.3 months.

The follow-up visits were at 1 week, 2 weeks, 4 weeks, 3 months, 6 months and at 1 year postoperatively. After 2 weeks we removed the stitches and they were immobilized in backslap for 4 weeks and range of motion exercises increased progressively, oral anticoagulant was administered daily during immobilization. No weightbearing was allowed for 12 weeks, followed by partial weightbearing (10-15 kg) for another 2 weeks. Full weightbearing was authorized after another 2 weeks, supported by physical therapy for unaided walking, ankle and subtalar joint motion, strengthening, and coordination.

Standard radiographic projections (ankle lateral, calcaneus axial) were obtained at least 4 and 8 weeks and 6 months postoperatively and at the latest follow-up.

In addition, Böhler's and Gissane angles was assessed on preoperative radiographs, postoperatively, and at the latest follow-up. Loss of reduction was defined as a change of 5 degrees or more on any radiographic views.

CT scan assessment of articular surface wase done after 4 weeks.

4. Results

- Regarding Radiological evaluations of calcaneus angles of the studied patients, preoperative mean of Bohler angle was12.05° and mean of Gissane angle was 135.70°. after surgery, the mean of Bohler angle became 28.15° while mean of Gissane angle became 122.25° (**Table 1,2)**.

Table (1) Radiological evaluations of calcaneus angles preoperative of the studied patients**.**

	Minimum	Maximum	Mean	Std. Deviation
Bohler angle preoperative	3.00	19.00	12.0500	4.58229
Gissane angle preoperative	125.00	147.00	135.7000	6.48967

Table (2) Radiological evaluations of calcaneus angles postoperative of the studied patients.

	Minimum	Maximum	Mean	Std. Deviation
Bohler angle postoperative	22.00	34.00	28.1500	2.961
Gissane angle preoperative	125.00	147.00	122.250	6.470

- Regarding patient's outcome according to AOFAS scale, 14 (70%) of patients showed excellent results while 4 (20%) of patients showed good results and 2 patients (10%) showed fair results (**Table 3)**.

Table (3) patients' outcome according to AOFAS scale

outcome	**Excellent (90-100)**	**Good (80-89)**	**Fair (70-79)**
Frequency	14	4	2
Percent	70%	20%	10%

- After 6 months follow up, mean of AOFAS score was 90.25 ranged from 74 to 99. (**Table 4)**.

Table (4) Evaluations of AOFAS, Bohler angle and Gissane angle 6 months postoperative of the studied patients.

	Minimum	Maximum	Mean	Std. Deviation
Bohler angle 6m postoperative	23.00	31.00	27.2500	2.17340
Gissane angle 6m postoperative	114.00	131.00	122.6500	5.48946
AOFAS 6 months postoperative	74.00	99.00	90.2500	8.06471

Complications in our Study

- 3 patients had iatrogenic peroneal tendinitis from prominent adjacent implants. Nonoperative management includes nonsteroidal anti-inflammatory medication, and physical therapy for manual mobilization, stretching and eversion strengthening, one of them are planned for a peroneal tenolysis and/ or removal of the symptomatic implants may be necessary.
- 1 Patient had delayed range of motion of the ankle and subtalar motion but regained full range after 4 months.
- 1 patient had radiological heel varus **(Fig. 7)**.

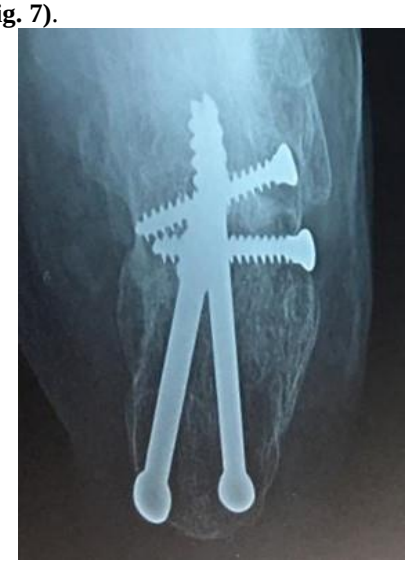

Fig. (7) Post-operative X-ray heel axial view show varus alignment.

- 2 patients with fair reduction, with minimal pain and no affection of range of motions, which may later have subtalar arthritis in long standing follow up **(Fig. 8)**.

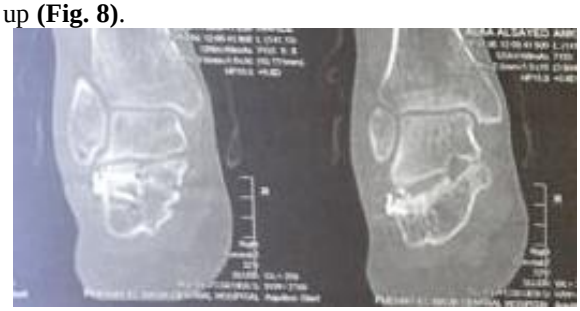

Fig. (8) Step off of articular surface reduction.

5. Discussion

According to the current study, fixation was done using mini-fragment plat and/or cortical screws 4.5 mm for articular butters, and cortical screws 4.5 mm and/or canulated partially threated 6.5 cancellous screws for varus malalignment. Marked improvement in Böhler angle wase noticed in all patients, the mean preoperative angle was12.05°, and postoperative became 28.15°, which is within the 20° to 40° recommended in Rockwood and Green, our results compare favorably with the previous study, which showed that restoration of the Böhler's angle leads to better functional outcomes [13].

Less invasive techniques should reduce wound infection and sural nerve lesions. **Nosewicz T**.**et al** [14] reported in systematic review and meta-analysis of the sinus tarsi and extended lateral approach in the operative treatment of displaced intra-articular calcaneal fractures described significantly less postoperative wound healing complications when the sinus tarsi approach was used. The risk of developing a wound infection decreases 80% with the sinus tarsi approach (relative risk reduction). Furthermore, the authors differentiated between minor and major wound complications and did not find any major wound complications with the sinus tarsi approach, whereas 29% of the wound complications were classified as major (deep infections including osteomyelitis, infected implants, plate fistula, or extensive wound edge necrosis all in need of implant removal) following the extended lateral approach [(14)]. In current study, no wound complication was seen which was similar to that in **Xia et al** reported no wound complication in the sinus tarsi approach [15].

Meta-analysis by **Zeng Z et al** of randomized controlled trials also compared the minimally invasive versus the extensile lateral approach for Sanders type II and III fractures, the pooled data showed that the minimal invasive approach reduced the absolute risk for wound complications by 15.3% (absolute risk reduction), the risk of developing a wound complication was reduced by 88% (relative risk reduction) [16].

Incomplete reduction and unstable fixation in complex fractures is discussed as the major concern of less invasive approaches [(11)]. But **Dingemans SA. et al** in a biomechanical review found no clear benefit for locking plates except in osteoporotic bone and concluded that all fixation methods (conventional plates, locking plates, unicortical screws, bicortical screws, small fragment plates, intramedullary devices, augmented screws, compression bolts, longitudinal screws added to lateral plates) seemed to be biomechanically adequate [(17)].

In the current study, after 2 to 1 year's follow up (main 17 months) follow up all 20 patients had a correctly restored calcaneal length, height, width, and angulation, with anatomically restored posterior facet, only 2 patients (10%) (1 mm or less residual displacement of the joint line), one patient had heel varus (5%). No nonunion occurred. The results were obtained on standard radiographic projections (ankle anteroposterior/lateral, calcaneus axial) and CT-based study.

Nosewicz T. et al [(18)] demonstrated fracture reduction based on CT study (step-off, <1 mm; defect, <5 mm; angulation, <5 degrees) in 64% of the patients and no loss of reduction at final follow-up (1 year) [(18)], **Scott AT. et al** [(19)] assessed reduction of calcaneal fractures on lateral radiographs and CT pre- and postoperatively, Postoperative CT showed a congruent subtalar and calcaneocuboid articulation in 91% (articular step-off, <2 mm) [(19)], This Finding was in line with current study.

The calcaneus is critical to hindfoot function. The subtalar joint plays a major role in hindfoot motion as it is the main articulation for inversion/eversion [(20)]. **Kingwell et al** demonstrated that the early amount of subtalar motion (12 weeks) after calcaneal fracture is significantly related to patient satisfaction at 2 years [(20)].

In addition, **Van Hoeve et al** noted that the range of motion of the subtalar joints was significantly related to both the quality of reduction (postoperative CT) and functional outcome [(21)].

The present study demonstrated no restrictions in hindfoot motion in all patients. Subtalar joint motion was recorded as percentages of the uninjured limb and used to calculate the AOFAS score. In comparison, **Nosewicz et al** [(18)] found "normal/mild" and "moderate" restriction

in hindfoot motion in 72% even though they used continuous passive motion (CPM) (dorsiflexion/plantarflexion and pronation/supination) in addition to compression postoperatively. These results would indicate that CPM immediately after the operation is not superior to immobilization in a short leg cast for 4 weeks (as in current present study).

Standardized and validated scores should be used to compare different national and international studies. The AOFAS hindfoot score was chosen for clinical and functional outcome documentation from the beginning, 18 years ago, because it is easy to use and has been reported on in multiple previous studies [(22)]. Although it has not been validated, our results are comparable to those of other studies because it is commonly used. The mean AOFAS score of current study was 90.25(ranged from 74 to 99) after 6 months follow up. These results are comparable with the AOFAS score reported by **Nosewicz et al** [(18)] 86 (range, 57-100). In another study, of the total 40 cases operated by **Patil et al**. using the minimally invasive techniques, post-operative AOFAS score was found to be good in 30 cases, 9 cases were fair and one had a poor outcome [(23)].

The current study also comparable to study by **Chul Hyun Park et al.** [(24)] who followed up 20 Sanders type II cases for one year. There was significant improvement in the postoperative Bohlers angle and Gissane's angle with AFASS scoring of 25% excellent, 50% good and 25% fair outcome, but in this current study AOFAS score, 1**4** (**70**%) of patients showed excellent results while (20%) of patients showed good results and **2** patients (1**0**%) showed fair results.

This study confirms that the function of the calcaneus and subtalar joint can be restored by open reduction and internal fixation through minimal invasive sinus tarsi approach in patients with a displaced intraarticular calcaneal fracture. But functional outcome was better in Sanders type II fractures than Sanders type III and Ⅳ fractures, so we recommend this technique to be limited to whom with Sanders type II only and further comparative studies with wider scale are needed to confirm these results.

Summary

Sinus tarsi approach is a less invasive method for treatment of calcaneal fractures. It permits good visualization of the fracture, and allows anatomic reduction of articular surfaces with a decrease of wound complications and shorter waiting time before surgery. It is a valid option of treatment for displaced intra-articular calcaneal fractures with more advantage to Sanders type II.

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